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Power and pollutant exposure in the context of American Indian Health and Survival

LM Schell^{1,2,3}, MV Gallo^{1,3}, and HD Horton⁴

¹Department of Anthropology, University at Albany, SUNY, Albany, NY 12222

²Department of Epidemiology and Biostatistics, University at Albany, SUNY, Albany, NY 12222

³Center for the Elimination of Minority Health Disparities, University at Albany, SUNY, Albany, NY 12222

⁴Department of Sociology, University at Albany, SUNY, Albany, NY 12222

Abstract

American Indians and Alaskan Natives (AI/AN) are a highly diverse group in terms of culture and language but share a history of oppression and attempted extermination that has left many with a legacy of poverty and poor health. Cultural and biological survival are important issues for many AI/AN groups. Using US criteria, AI/AN groups are more likely to be poor. The US National Center for Health Statistics reports that US AI/ANs have higher mortality and morbidity rates than the US population. While all groups racially defined by the US National Center for Health Statistics are experiencing a decline in fertility since 1983, AI/ANs seem to be suffering a substantially greater and earlier decline in fertility. Given the importance of fertility in the survival of AI/AN communities, it is important to identify the source of this decline. A recent study of one AI/AN group living along the St. Lawrence River found that obesity and exposure to a particular group of polychlorinated biphenyls were the factors most highly associated with indicators of impaired fertility. Economic factors are often cited as reasons for fertility declines, however in this situation these other factors may have either primary or contributing roles. If the associations with obesity and toxicant exposure are confirmed, intervening on these factors might be important steps in stemming continued declines in fertility.

Introduction

This paper reviews the health of American Indians and Alaskan Natives (AI/AN) living in the United States (US). While the poor health of AI/AN has many causes and originates in centuries of physical, social and economic mistreatment, the role of environmental exposures and their biological effects has not been investigated by human biologists. In addition to reviewing general indices of health in the AI/AN population, this paper considers the role of environmental exposures in contributing to an apparent decline in fertility and employs some early results from a study of reproductive health among women of the Akwesasne Mohawk Nation to suggest causes of the decline. A decline in fertility is a serious problem for all AI/AN people who continue the centuries long struggle for cultural and physical existence.

American Indian groups experience some of the worst environmental injustice of any race/ethnic group in the US (Hoover 2012; Mascarenhas, 2007). The US EPA (cited in Hoover 2012) defines environmental justice as, “the fair treatment and meaningful involvement of all people regardless of race, colour, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.” For many reasons waste disposal sites and polluting industries are subject to less regulation when placed on or near indigenous communities (Hoover, 2012). Thus, more native communities suffer exposures. In general, environmental injustice is greater in societies with greater power inequalities such that disadvantaged groups including native peoples and other minority groups suffer disproportionate exposures (Agyman, 2002; Boyce 1999). Additionally, mitigating the environmental problems, usually a slow and tangled legal process in the US, is slower in AI/AN communities compared to non-tribal ones (Hoover, 2012). The result is greater exposure to environmental hazards with more negative health consequences in the exposed communities.

The American Indian/Alaskan Native Populations

The United States (US) census estimates that in 2014 there were approximately 6.5 million Americans Indians/Alaskan Natives (AI/AN) residing within the borders of the United States. This is approximately equal to about 2% of the US population. In 2010 when the last census was performed, 49% gave AI/AN as their only race. (The word race is used here only because the US National Center for Health Statistics uses the term. Despite our dislike for such terms implying biological identity, we employ the race labels [white, Black etc.] used by the US Center for Health Statistics to ensure fidelity to the data they have presented and avoid confusion). Of the 2%, 20 – 33% live on a reservation. Of those giving AI/AN and another “race” as their identity, approximately 20% live on a reservation. Thus, most AI/ANs who were counted when the census was conducted did not live on a reservation. The figures have to be considered in light of enumeration problems for the US census. Some Native people prefer not to be counted by the census as to be included would mean accepting the notion that they are part of the US nation when in fact many regard themselves as part of a sovereign Indian nation.

The Native American population of North America is an exceedingly diverse group of peoples. Anthropologists have traditionally divided the population on the basis of language and culture areas. There are 10 culture areas in, or partly in, the US and more south of the Rio Grande River (<http://www.native-languages.org/culture-areas.htm>). It can be said that the diversity in language and culture within Native North America is as great as in India where the WALS database lists 140 languages in 9 language families (Dryer et al. 2013). For the US, the database lists 188 languages (counting Yupik, St. Lawrence Island [technically part of Eurasia, not North America] but not including non-Native languages, nor Hawaiian Creole, Plains Indian sign or American sign languages) and 33 language families.

Survival and Sovereignty

Despite the diversity, all the groups share a common history of oppression and their attempted extermination. Ethnic cleansing is a modern term used to describe the process of

removing all traces of another's culture and people. American Indians have been subject to ethnic cleansing for over 500 years. While many are familiar with events in earlier historical periods and their legacy, the fact that it is an ongoing process is far less familiar.

American Indians have been subject to the forced removal of their children to off-reservation boarding schools. Originally begun in 1860 with on-reservation schools, off-reservation schools were thought to be a better way to "kill the Indian and save the man". The most famous of the off-reservation schools was the Carlisle School established in 1879. In the 1880's the government operated some 60 schools for 6200 children (http://www.nrcprograms.org/site/PageServer?pagename=airc_hist_boardingschools). Students were given uniforms, white names, white foods and haircuts (no braids), and were not allowed to speak in their native languages. In fact, no vestiges of tribal life were allowed to remain in the school. Academic teaching gave way to vocational training and over time this gave way to children providing free labour to local families and businesses. Discipline was severe. Finally, American Indian parents regained the legal right to deny their children's placement in off-reservation schools via the Indian Child Welfare Act that was passed in 1978!

Equally or more egregious was the practice of forced sterilisation of American Indian women. In the 1970's American Indian women were subjected to sterilisations without their consent. Four Indian Health Service facilities performed some 3,406 sterilisations between 1973 and 1976 (GAO 1976), although this number is an underestimate (Lawrence, 2000). On a per capita basis this is equivalent to sterilising 452,000 non-Native American women (Rutecki, 2010).

American Indians and Alaskan Natives in the 21st century continue to practice their native culture as much as possible. There are pow-wows with displays of crafts, foods, music, art and native dance competitions open to the public. There are tribal websites to disseminate information on community activities and resources, and organised meetings of related tribes and traditional ceremonies and other activities that are only open to tribal members.

Cultural preservation is a high priority for most, even the highest priority. However, there are many different forces that continue the ethnic cleansing process that began in 1492 and accelerated after 1620. Eradication of American Indian cultures through forced removal of populations, by forced placement of children in boarding schools and sterilisation of adults are only three of the extensive efforts by the US and local governments. Today, the most usual forces are those we are all subject to but without much notice. The mainstream media present images of wealth, comfort and happiness for us all to seek. An advertisement for air conditioning or a brand of breakfast cereal seems innocuous but they present a decidedly eurocentric image of comfort and success.

In *Custer Died for Your Sins* (Deloria, 1969), Deloria explains why Native Americans were not in the civil rights fight with the African-Americans during the 1960's: while the African-Americans wanted their "piece of the pie," that is, their share of the benefits of modern culture, Native Americans wanted none of it. The preservation of the people and their culture

is key. Thus poverty, in the sense of having little or few of the benefits of modern mainstream society, has a different meaning when those benefits are all not strongly desired.

Economic Well-being of modern AI/AN in the US

Poverty in this context is only the absence of economic well-being and does not refer to spiritual, social or any other dimension of social life. In other words, poor people may be very rich in non-economic ways.

Modern poverty is rife within the communities of North American Indians and Alaskan Natives. The average poverty rate for families from the American Community Survey 2011–2013 is 9.2 for the nation while for individuals it is 12.4 (Table 1). The average poverty rates for the 10 largest Indian reservations are 42.7 (+/– 10.0) for families and 38 (+/– 11.4) for individuals. These rates are 9.2 times the national average for families and 12.4 times the national average for individuals. The American Community Survey for 2011–2013 reported that 24.3% of AI/AN families live in poverty, and 29.2% of all AI/AN people live in poverty. Among families in female-led households the poverty rate jumps to 55% in families with children under 5 years of age and 49.5% with related children under 18 years of age (US Census Bureau, 2014).

A related statistic describes the levels of formal educational attainment among American Indians and Alaskan Natives. Among AI/AN youth less than 25 years old, 11% did not finish high school, and of those 25 years of age and older, 17.6% obtained a bachelor's degree (Figure 1) and only 4.7% obtained a higher degree (not shown). Only the Hispanic US population has more unfavourable rates of formal educational attainment (<http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk>).

An Overview of Health

The lack of economic well being in communities is reflected in the rates of disease and deaths at all ages. The following comparisons are based on reports from the US government agencies, the Centers for Disease Control and Prevention (CDC), and the National Center for Health Statistics (NCHS). Their presentations of morbidity or mortality rates by ethnic/racial groups are usually not accompanied by tests of significance, however the values represent populations rather than samples and ones of considerable size. The prevalence of heart disease among AI/AN (self-reported) was the highest of whites, African-Americans, Asians and Hispanic Americans in six of seven biennial assessments between 1997 and 2013 (Figure 2). Only in 2010–2011 did the prevalence drop lower, albeit insignificantly, than both African-Americans and whites to 10.3 per 1,000 people (<http://www.cdc.gov/nchs/american.htm>). The related disease, stroke, had the greatest prevalence across the 1997 to 2013 years in 4 of the 6 yearly comparisons (Figure 3).

Compared to the US white population, mortality rates for AI/AN populations are from 60% to 100% higher (Day and Lanier 2003; Kunitz 2008). In 2012, the most recent data available from US government agencies, the top two causes of death among AI/AN were first, malignant neoplasms and second, diseases of the heart whereas for whites the order was reversed. Third among AI/AN were accidents which is 4th among whites. More discrepant

were diabetes mellitus and chronic liver disease and cirrhosis. Diabetes mellitus was the 4th leading cause of death among AI/AN, but 7th among whites. Chronic liver disease and cirrhosis was 5th among AI/AN, but 11th among whites. It is important to note that while these statistics are issued by the US government, they suffer from some serious problems. Race classification on death certificates is often incorrect and the effect in the case of AI/AN is an underestimation of deaths and death rates by 30%! (Heron 2015).

Adult health begins with early life experience

Given the importance of early life experiences in influencing adult health, the health of AI/AN mothers and newborns bears consideration. AI/AN mothers have the highest rate of gestational diabetes second only to Asian/Pacific Islanders and about 1.5 times the rate among African-Americans (Figure 4). Their rate of pregnancy weight gain above 40 lbs. is little different from whites and African-Americans. Their rate of weight gain less than 11 lbs. is similar to African-Americans but substantially larger than those of whites and Asian/Pacific Islanders. AI/AN mothers are more likely than any other US group to be less than 20 years of age and also likelier than any other to have four or more children (Figure 5). They are nearly as likely as African-American mothers to be unmarried and about twice as likely as whites.

Despite the disadvantage implied by the combination of young mothers, large families and unmarried status of mothers, the rate of low birth weight is nearly as low as that of whites and lower than all other US groups, while the rate of high birth weight is the highest of all groups (Table 2). These recent statistics are consistent with reports from some 50 years ago (Adams and Niswander, 1973). Of reported live births between 1994 and 1996, 12.7% were high birth weight compared to 10.3% for all races (Indian Health Service, 1997). This suggests that the relatively high frequency of large babies is not a new phenomenon among AI/AN.

Given the frequent large size of AI/AN babies, one might expect favourable statistics of newborn survival. However, infant mortality rates are high and second only to African-Americans. The rate is 1.65 times that of whites. Similar relationships hold for neonatal deaths and post-neonatal deaths (Table 3; Matthews et al., 2015).

Statistics reflecting reproduction are no more favourable. The fertility rates of all US groups have declined according to the National Vital Statistics reports. However, the decline is the steepest for AI/ANs. In 1983 they had the highest birth rate (number of births per 1000 women of all ages), 20.6 per thousand women, but by 2013 the rate had fallen to half that, 10.3 per thousand women. The decline was more than twice that of the next highest decline, among Asian or Pacific Islanders, and more than four times the decline experienced by African-Americans (see Figure 6; Martin et al. 2015).

Examining age-adjusted fertility rates reveals the particular age groups in which the decline is steepest. All racial groups experienced substantial declines among the 15–19 year olds but AI/ANs and African-Americans experienced the steepest declines, usually twice that of whites or Asian or Pacific Islanders (Figure 7). In the 20–24 years of age group, both

AI/ANs and Asian or Pacific Islanders experienced steep declines, about twice that of any other group. Significant differences are especially apparent in the 25–29 age group. Within this age group, the AI/AN birth rates decline from 145.5 births per thousand women in 1983 to 78.9 births in 2013 (Figure 7; Martin et al., 2015). Whites and Blacks in this age range experienced small increases in birth rates while Asian and Pacific Islanders experienced a decline equal to two thirds of the AI/AN group. In older age groups, AI/ANs continued to experience a decline but not as great as in younger age cohorts while the other groups experienced increases that were often substantial.

The reasons for these declines are not known. First, the statistics used in US fertility/birth reports are period and not cohort data. Hence, this data relates to short intervals of time and is subject to tempo effects as opposed to lifetime experience. Conversely, these data do reflect current estimates highlighting yearly variations due to transient influences and not estimates related to an earlier period. The usual explanations for the national decline in births are economic recession, smaller families, having children later in life and longer birth intervals (Taylor et al. 2011). Given an emphasis on the survival of the AI/AN population, this explanation may not be adequate. Some preliminary results from a study of menstrual cycles among women of the Akwesasne Mohawk Nation suggest some other possible causes.

Preliminary Results from the Reproductive Health Study at Akwesasne

A study of women's reproductive health with the Akwesasne Mohawk Nation was initiated because of concerns expressed by Akwesasne women that they were becoming pregnant but then losing the pregnancy very early or were not becoming pregnant at all. Our results from earlier studies showing earlier sexual maturation in girls and reduced testosterone levels in boys in relation to certain toxicant levels suggested that toxicant levels needed to be considered as possible causes of women's reproductive problems (Denham, et al. 2005; Schell et al., 2014). Further, the study of Akwesasne women has relevance for AI/AN women generally owing to their greater exposure to environmental toxicants.

The Akwesasne Mohawk Nation is located along the St. Lawrence River in North America where industries developed after the creation of the St. Lawrence Seaway (for more background see, Schell et al. 2003). The Nation borders New York State, Ontario and Quebec Canada. Since the mid-1980's the community has been concerned about the effects of pollutants emanating from upstream industries that have entered the food chain, the water and air. Previous studies of toxicant levels in the community have shown that there are detectable levels of the pesticides DDE (the metabolite of DDT that is stored in the body) and hexachlorobenzene (HCB). The pollutant that is highest relative to the US population is the group of polychlorinated biphenyls (PCBs). Previous analyses have determined that many people in the community have levels of PCBs in their blood. The average PCB level among the women of reproductive age studied by our group approximates the 90th centile of the CDC reference population.

There are many ways that exposure could occur. PCBs used in upstream industries have been disposed of improperly, entering the river and local food chain. One study of young

adults showed that those who reported consumption of locally caught fish and some other local wildlife in the past year had higher blood levels of PCBs (Schell et al. 2012). Breastfeeding is associated with higher levels of persistent PCBs among adolescents and young adults (Gallo et al. 2011; Schell et al. 2003) despite the fact that the breastfeeding had ceased some 9 to 19 years before the blood was drawn and measured.

PCBs are a group of molecules that can take 209 different forms (congeners). The congeners differ in the degree of chlorination, location of the biphenyl positions that are substituted with chlorine. These characteristics greatly influence the toxicity and persistence of the molecule. Our statistical analyses are focused on the congeners found in 20% or more of the sample. The congeners have been grouped according to the number and position(s) of chlorine substitutions to reflect their activity, specifically those congeners thought to have endocrine disruptive properties and activities. One group in particular are the congeners with a single chlorine substitution that is at the ortho position on one of the benzene rings.

Some preliminary results are available from the study of adult women 21 through 38 years of age, conducted between 2010 and 2013. Participants contributed saliva on first rising every day for the duration of one menstrual cycle. Venous blood was drawn on day 3 of their cycle and they were interviewed and examined to obtain information on size, and behaviours such as sleep and diet. Ovulation was determined by changes in salivary estradiol and progesterone according to an often used assessment method (Lipson and Ellison, 1996).

Our preliminary analyses show that women who did not ovulate in the menstrual cycle had significantly higher levels of mono-ortho substituted PCBs (mean = 0.24 ppb; $t = 2.38$, $p = 0.02$; Figure 8). Women with detectable levels of these specific PCBs were twice as likely to not ovulate as compared to women with undetectable levels.

Non-ovulating women also had significant greater BMI ($t = 4.42$; $p = 0.0001$) and were younger though not significantly so ($t = -1.89$; $p = 0.06$). A multiple logistic regression analysis with these three factors indicated that as PCB levels increased, the risk of not ovulating increased also (Figure 9). A 20% increase from the mean in mono-ortho PCBs increases the odds of not ovulating by 18%.

Discussion and Conclusion

These results relating menstrual cycle characteristics of Akwesasne Mohawk women to obesity and the serum level of a particular group of PCB congeners suggests that these two factors may contribute to changes in fertility. However, these are statistical associations and a cross sectional study cannot determine causality. Additionally, these results are preliminary and additional analyses possibly including additional covariates are required for confirmation.

There is evidence in the literature that supports these preliminary results. Obesity is well known to interfere with ovulation and inhibit reproduction (Parahar 2003). There is increased aromatisation of androgens to estrogens in obese women. Gonadotropin secretion is affected. Hyperandrogenemia in obese women stems from insulin resistance and hyperinsulinemia (Dag and Dilbaz 2015). Coincidentally the decline in fertility in the AI/AN

population coincides temporally with the rise of the obesity epidemic nationally. In addition, certain toxicants are known to affect the reproductive system including lead, DDT (DDE), and PCBs (Denham et al. 2005; Reutmann and Meadows 2013; Selevan, et al. 2003). While high PCB serum levels in women have been shown to lengthen menstrual cycle length (Cooper et al. 2005), even low concentrations of p,p'-DDE and HCB have been positively correlated with failed fertility in women (Younglei et al. 2002), and the induction of anovulatory cycles as well as the suppression of estradiol levels in non-human primates (Muller et al. 1978) respectively.

The decline in fertility among AI/AN is occurring in the context of the AI/AN struggle for survival and desire for growth. Whether due to obesity, pollutant exposure or both, the goal of restoring the AI/AN populations and cultures is impeded by modern conditions imposed by the larger, more dominant culture in the US. The newer factors of obesity and pollutant exposure may be new contributors to the forces hindering the restoration of AI/AN cultures and population growth. However, while obesity and pollutant burdens are difficult or impossible to reverse by individuals, preventive measures applied at the community level may have beneficial effects for future generations.

Further research is needed to support or discredit the hypothesis that obesity and pollutant exposure are responsible for the fertility decline. Additional information regarding alternative hypotheses such as socioeconomic factors should be considered. Another simple step could be testing the association between pollutant exposure and declines in specific areas where AI/ANs reside. A similar analysis could be conducted with regard to obesity although the obesity epidemic may show less diversity among AI/AN communities than pollutant exposure.

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Figure 1.

American Indian, Alaskan Native Education Achievement

Source: U.S. Census Bureau, Current Population Survey, 2014 Annual Social and Economic Supplement (Table 3; <https://www.census.gov/hhes/socdemo/education/data/cps/2014/tables.html>)

Figure 2.

Prevalence of heart disease:1997–2013, (respondent based).

Source: National Center for Health Statistics, 2015 (<http://www.cdc.gov/nchs/american.htm>)

Figure 3.

Prevalence of stroke: 1997–2013, (respondent based).

Source: National Center for Health Statistics, 2015 (<http://www.cdc.gov/nchs/american.htm>)

Figure 4.

Selected medical characteristics of births, by race of mother, US, 2013.

Source: National Center for Health Statistics, 2015 (<http://www.cdc.gov/nchs/american.htm>).

Figure 5. American Indian/Alaskan Native mothers more often are teens, have more children, and are not married.

Source: Martin et al., 2015

Figure 6.
Fertility rates by race of mother, US, 1983–2013.
Source: Martin et al., 2015

Figure 7.
Age-adjusted fertility rates by race: 19983–2013.
Source: Martin et al., 2015

Figure 8. Differences between women who ovulated (OV) and those who did not (non-OV).
* $p < 0.05$; ** $p < 0.01$

Figure 9.

Probability of not ovulating in relation to mono-ortho PCB levels in Akwesasne women.

^aSum of Mono-Ortho PCBs at or above ROD of 20% (ppb; mdl/sqrt2) IUPAC #s: 28, 31, 33, 56, 63, 74, 70, 66, 105, 114, 118, 156

Rates of poverty among the largest American Indian and Alaskan Native reservations in the US (*Source*: 2011–2013 American Community Survey; <http://www.census.gov>).

Table 1

<i>National Average</i>	Location	Poverty rate: Families with children	Poverty Rate: Individuals
		9.2	12.4
Navajo Indian Reservation	Arizona, New Mexico, and Utah	46.5	42.9
Uintah and Ouray Indian Reservation	Utah	54.4	20.2
Tohono O'odham Indian Reservation	Arizona	44.3	46.4
Cheyenne River Indian Reservation	South Dakota	42.3	38.5
Standing Rock Indian Reservation	South and North Dakota	41.2	40.8
Crow Indian Reservation	Montana	31.5	30.5
Wind River Indian Reservation	Wyoming	22.6	20.9
Pine Ridge Indian Reservation	South Dakota	52.8	53.5
Fort Peck Indian Reservation	Montana	38.5	35.3
San Carlos Indian Reservation	Arizona	52.6	50.8

Source: US Census Bureau; 2011–2013 American Community Survey; <http://www.census.gov>

Table 2

Rates of low and high birth weight among American Indians and Alaskan Natives in the US.

	Low birth weight ^a	High birth weight ^b
All races	8.0	8.0
White	7.0	8.9
African American	12.8	4.5
American Indian Alaskan Native	7.5	9.8
Asian or Pacific Islander	8.3	4.8

^aLBW: <2,500 gms;

^bHBW:>4,000 gms

Source: Martin et al., 2015

Table 3

Infant, neonatal and post-neonatal mortality rates (number of deaths per 1,000 births), US, 2012.

2012	Infant deaths	Neonatal deaths	Postnatal deaths
<i>All mothers</i>	<i>6.0</i>	<i>4.0</i>	<i>2.0</i>
White	5.0	3.3	1.7
Black or African Americans	11.2	7.5	3.7
American Indian/Alaskan Native	8.4	4.9	3.5
Asian or Pacific Islander	4.1	2.9	1.2
Hispanic or Latina	5.1	3.6	1.5

Source: Matthews et al., 2015